

COOLING CIRCUIT FOR AN INTERNAL COMBUSTION ENGINE

Background Information

The present invention relates to a cooling circuit for an internal combustion engine. A water-cooled internal combustion engine of a motor vehicle is cooled by a coolant, usually water including various additives, which is transported through the engine block and the cylinder head of the internal combustion engine by a main coolant pump. From the cylinder head, the coolant reaches a radiator or, alternatively, a heat exchanger. A cooling circuit for an internal combustion engine, which allows the cooling capacity in different areas of the engine to be adjusted to the actual cooling requirements, is known from DE 199 38 614 A1.

15 Advantages of the Invention

The present invention provides a cooling circuit for an internal combustion engine that enables the internal combustion engine to be brought to operating temperature as quickly as possible after startup without the danger of local overheating. In addition, the cooling circuit according to the present invention allows heat to be supplied very quickly to the heat exchanger, via which heat is supplied to the vehicle interior. To do this, the return channel from the second coolant circuit, which supplies coolant to the heat exchanger, is connectable to either the return channel or the flow channel of the first coolant circuit, which discharges waste heat from the internal combustion engine via the radiator.

Connecting the second return channel of the second coolant circuit to the first flow channel of the first coolant circuit, while simultaneously taking the second return channel out of service, produces a small cooling circuit that flows 5 through only the cylinder head of the internal combustion engine, thus preventing the cylinder head from overheating and allowing the engine block of the internal combustion engine to reach its operating temperature as quickly as possible.

10 In a first embodiment of the cooling circuit according to the present invention, a main coolant pump is provided in the first coolant circuit, and an auxiliary coolant pump is provided in the second coolant circuit, so that, if necessary, the discharge of heat from the internal combustion engine is 15 adjustable to the requirements.

According to further advantageous embodiments of the present invention, a bypass line for circumventing the radiator is provided in the first coolant circuit, it being especially 20 advantageous to open or close the bypass line in a temperature-controlled manner so that the temperature of the internal combustion engine may be maintained at a constant level largely independently of the ambient conditions and the internal load of the internal combustion engine.

25 To ensure more comfortable heating of the vehicle interior, the auxiliary coolant pump may be regulated or controlled in a temperature-controlled manner.

30 Optimum performance of the cooling circuit is achieved by operating the cooling circuit according to the following procedure:

35 - Detection of the temperature of the internal combustion engine.

- Deactivation of the main coolant pump and the auxiliary coolant pump; setting of the distributor to its first position if the temperature of the internal combustion engine is less than a first threshold value.

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- Deactivation of the main coolant pump and activation of the auxiliary coolant pump; setting of the distributor to its first position if the temperature of the internal combustion engine is greater than or equal to the first threshold value and less than a second threshold value.

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- Activation of the main coolant pump and deactivation of the auxiliary coolant pump; setting of the distributor to its second position if the temperature of the internal combustion engine is greater than or equal to the second threshold value.

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Operating the cooling circuit of the present invention according to this procedure ensures that the internal combustion engine reaches its operating temperature as quickly as possible, the heat exchanger is supplied with heat as soon as possible and, upon reaching the operating temperature, the internal combustion engine is adequately cooled to avoid overheating in all operating states.

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To exclude local overheating during the cold start phase of the internal combustion engine, it is possible according to a further refinement to activate the main coolant pump and deactivate the auxiliary coolant pump and to set the distributor to its second position if the power output by the internal combustion engine exceeds a preset limit value. The power output by the internal combustion engine may be calculated, for example, on the basis of the product of the rotational speed of the internal combustion engine and the torque output by the internal combustion engine.

Alternatively, the torque or the rotational speed alone may be used as the criterion for activating the main coolant pump.

As a further security measure, the main coolant pump is activated, at the latest, upon reaching a maximum pump deactivation time, which is preferably determined as a function of the engine temperature when starting the internal combustion engine.

10 Drawing

Further advantages and advantageous embodiments of the present invention are derived from the following drawing, the description thereof, and the patent claims.

15 Figure 1 shows an exemplary embodiment of a cooling circuit according to the present invention in a first operating state;

20 Figure 2 shows an exemplary embodiment of a cooling circuit according to the present invention in a second operating state;

25 Figure 3 shows a cooling circuit according to the related art; and

Figure 4 shows a flow chart of a method for the optimum operation of the cooling circuit according to the present invention.

30 Description of the Exemplary Embodiments

A cooling circuit according to the related art is first described below on the basis of Figure 3, and its disadvantages are explained. Figure 3 shows a schematic

representation of a water-cooled internal combustion engine 1. Internal combustion engine 1 includes a cylinder head 3 and an engine block 5, both of which are cooled by a water cooling jacket that is not illustrated. Internal combustion engine 1 is cooled by a first coolant circuit 7, which includes a first flow channel 9, a radiator 11, and a first return channel 13. Installed in first coolant circuit 7 is a thermostat-controlled mixer 15, which, as a function of the temperature of first flow channel 9, more or less controls a bypass 17, which interconnects first flow channel 9 and first return channel 13 while circumventing radiator 11. The thermostat controlling mixer 15 is not illustrated in Figures 1 through 3, since thermostats of this type are adequately known from the related art. A main coolant pump 19, which conducts coolant to engine block 5 of internal combustion engine 1, is installed in first return channel 13.

The section of first flow channel 9 located between mixer 15 and radiator 11 as well as the section of first return channel 13 located between radiator 11 and bypass line 17 are represented by dotted lines in Figure 3 to indicate that mixer 15 has fully opened bypass line 17 and prevents coolant from flowing through radiator 11. Mixer 15 assumes this position when the temperature of flow channel 9 is still low, i.e., when internal combustion engine 1 is still in the cold start phase.

A heat exchanger 23 is supplied with waste heat from cylinder head 3 as needed via a second coolant circuit 21. Second coolant circuit 21 includes a second flow channel 25, a second return channel 27, and a second bypass line 29. The output of heat exchanger 23 may be regulated via a second mixer 31. This output regulation is known from the related art and is therefore not described in further detail.

An auxiliary coolant pump 33 is located in second return channel 27. Auxiliary coolant pump 33 is used, according to the related art, to increase the volume flowing through the heating circuit and thus to boost the heating capacity, 5 especially at low engine speeds. A thermostat 35, which measures the temperature in second flow channel 25, regulates the flow of cooling water through a wiper fluid heater.

As mentioned above, internal combustion engine 1 is still in 10 the cold start phase, since first bypass line 17 is fully open and coolant is not yet flowing through radiator 11. The directions of coolant flow in first flow channel 9, in first return channel 13 as well as in second flow channel 25, second return channel 27 and first bypass line 17 as well as second 15 bypass line 29 are illustrated by arrows in Figure 3. This representation shows that heat is exchanged between engine block 5 and cylinder head 3 within the internal combustion engine, due to the thermosiphon effect. As a result of this internal heat exchange, engine block 5 reaches its operating 20 temperature only at a slow rate, which is undesirable.

Figure 1 shows an exemplary embodiment according to the present invention of a cooling circuit according to the present invention in which this undesirable internal heat 25 exchange does not take place within internal combustion engine 1. The same components are identified by the same reference numbers as in Figure 3, and the remarks made in reference to Figure 3 also apply accordingly. In addition to the components known from the related art (see Figure 3), the cooling circuit 30 according to the present invention also includes a distributor 39. The second position of distributor 39 shown in Figure 1 establishes a hydraulic connection between second return channel 27 and first flow channel 9 via first bypass line 17. Main coolant pump 19 is deactivated, preventing coolant from 35 flowing through radiator 11. In this position, the coolant

flows from second channel 27 to cylinder head 3 via first bypass line 17 and first flow channel 9. The coolant is discharged from cylinder head 3 into second flow channel 25, where it reaches second return channel 27 either via heat 5 exchanger 23 or second bypass line 29. In this configuration of the cooling circuit according to the present invention, coolant does not flow through the engine block, which allows it to heat to the operating temperature as quickly as possible.

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However, cylinder head 3, which heats up faster than engine block 5, is adequately cooled to avoid impermissibly high operating temperatures in cylinder head 3. If necessary for thermal reasons, it is, of course, possible to also cool the 15 upper area of the cylinders (not illustrated) in the internal combustion engine via cylinder head 3, since this area also belongs to the combustion chamber and therefore is subjected to rapid heating already in the cold start phase. This configuration also ensures that hot coolant flows through heat 20 exchanger 23 as quickly as possible so that the latter may discharge heat as quickly as possible.

If not only main coolant pump 19, but also auxiliary coolant pump 33, is deactivated right at the beginning of a cold 25 start, cylinder head 3 may reach its operating temperature in just a few seconds or minutes, causing the emissions of internal combustion engine 1 to drop very quickly after the cold start begins. A temperature sensor for measuring the component temperature at the internal combustion engine, in 30 particular in the area of cylinder head 3, makes it possible to prevent impermissible overheating of the cylinder head. Once cylinder head 3 has reached an adequate temperature, auxiliary coolant pump 33 may be activated, and the state illustrated in Figure 1 occurs.

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Figure 2 shows the cooling circuit illustrated in Figure 1, distributor 39 assuming a first position and connecting second return channel 27 to first return channel 13. In Figure 2, the directions of coolant flow are also indicated by arrows. In 5 this state, main coolant pump 19 is activated so that engine block 5 is also cooled by coolant. Mixer 15 regulates the output of first coolant circuit 7 in the same manner as in the related art. The output of heat exchanger 23 is also regulated as known from the related art.

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The cooling circuit according to the present invention enables an internal combustion engine to reach its operating temperature as quickly as possible without resulting in disturbing internal heat convection. Different assemblies of 15 internal combustion engine 1 may therefore reach their operating temperatures at different rates. For example, cylinder head 3 usually reaches its operating temperature before engine block 5. As soon as cylinder head 3 has reached an adequate temperature, heat may be discharged via second 20 coolant circuit 21 and used to heat the vehicle interior via heat exchanger 23.

Figure 4 shows a flow chart of a method for operating a cooling circuit according to the present invention. Internal 25 combustion engine is started in a step S1. Immediately after the internal combustion engine starts, a maximum pump deactivation time $P_{off, max}$ is set as a function of the engine temperature. This takes place in step S2. A third step S3 checks whether the main coolant pump (abbreviated as HWP) is 30 deactivated for longer than maximum pump deactivation time $P_{off, max}$. If this is the case, main coolant pump HWP is activated. A fourth step S4 checks whether the power supplied to the internal combustion engine exceeds a limit value P_{limit} . If this is the case, the main coolant pump is also activated 35 to avoid overheating the internal combustion engine.

Otherwise, a step 5 checks whether temperature T_{eng} of the internal combustion engine is less than a first threshold value T_{s1} . If this is the case, main coolant pump HWP as well as the auxiliary coolant pump (abbreviated as ZWP) are 5 deactivated, and distributor 39 is set to its second position. This procedure takes place in a step S6. The query then starts over again at step S3. If temperature T_{eng} of the internal combustion engine is greater than first threshold value T_{s1} , main coolant pump HWP remains deactivated, auxiliary coolant 10 pump 33 is activated, and distributor 39 is closed. When distributor 39 is closed, this means that it has assumed its second position.

These operations take place in step S7. If temperature T_{eng} of 15 the internal combustion engine is less than a second threshold value T_{s2} but greater than first threshold value T_{s1} , the sequence starts over again before third step S3. Otherwise, main coolant pump HWP is activated, auxiliary coolant pump TWP is deactivated, and distributor 39 is opened, i.e., it assumes 20 its first position and connects first return channel 13 to second return channel 27.

Operating the cooling circuit of the present invention according to the method described in Figure 4 provides maximum 25 protection of the internal combustion engine against overheating, while simultaneously allowing it to reach its operating temperature as quickly as possible. The vehicle heating system may also be placed into service very quickly. Of course, the output of first coolant circuit 21 and second 30 coolant circuit 21 may be regulated not only according to the operating procedures described in Figures 1 through 3 and the method described in Figure 4, but also in any other manner that is known from the related art.